Assessing near-term efficiency potential of engine and vehicle technologies

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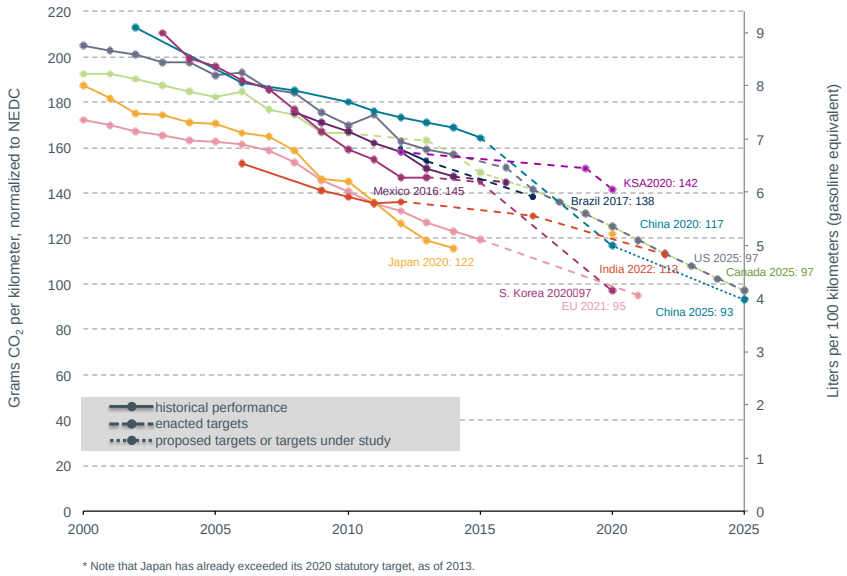
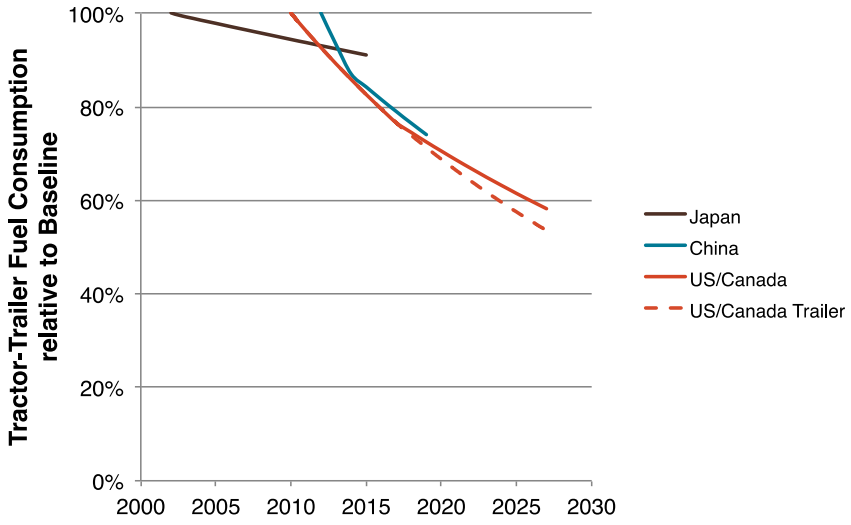
HDV efficiency regulations are at an early stage…



* Note that Japan has already exceeded its 2020 statutory target, as of 2013.

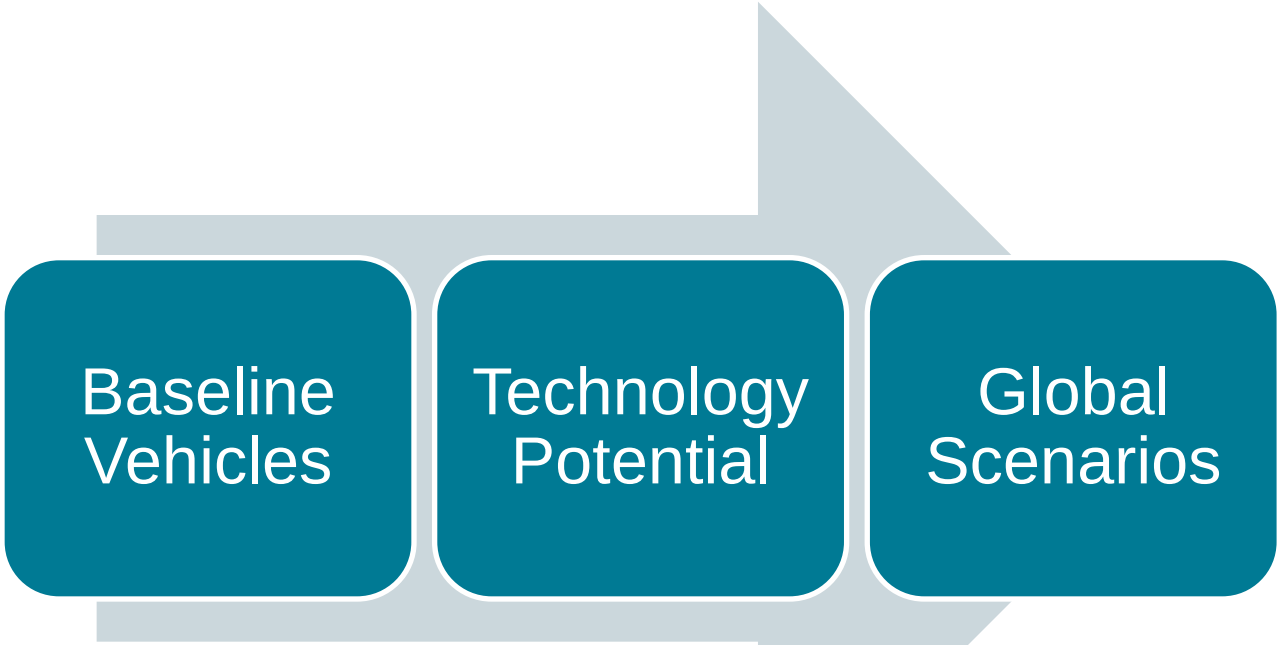
Passenger vehicle fuel consumption standards



Heavy-duty vehicle fuel consumption standards

Methodology

OBJECTIVE: Conduct technical analysis to incorporate HDV technology potential into GFEI targets.



Baseline Estimates

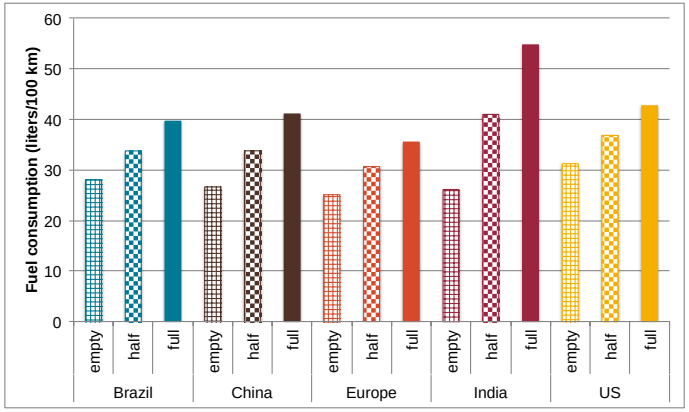
Typical vehicle characteristics

	Brazil	China	Europe	India	US
Gross vehicle weight (tonnes)	36	40	40	40	36
Vehicle curb weight (tonnes)	16.7	15	14.5	13	14.7
Maximum payload (tonnes)	19.3	25	25.5	27	21.3
Volume capacity (m^3)	108	86	96	93	114
Axle configuration	6x2	6x4	4x2	4x2	6x4
Typical trailer type	Dry bulk	Stake	Side curtain	Platform	Box van
Trailer axle number	3	3	3	3	2
Engine Displacement (liters)	13	10	12.8	5.9	15
Engine power (kW)	324	250	350	134	340
Engine emissions standard	Proconve P7[a] (NOx limit = 2 g/kWh)	China IV[b] (NOx limit = 3.5 g/kWh)	Euro VI (NOx limit = 0.4-0.46 g/kWh)	Bharat III[c] (NOx limit = 5 g/kWh)	EPA 2010[d] (NOx limit = 0.27 g/kWh)
Vehicle fuel efficiency standard	NA	China Stage 2	NA	NA	EPA/NHTSA 2014[e]
Transmission type[f]	AMT	MT	AMT	MT	MT
Transmission gears	12	10	12	6	10
Transmission gear ratios[g]	11.32 to 1	14.8 to 1	14.9 to 1	9.19 to 1	12.8 to 0.73
Rear axle ratio	4.38	4.11	2.64	6.83	3.70
Tire type	Radial	Radial	Radial	Bias	Radial
Tire size	295/80R22.5	12R22.5	315/80R22.5	10R20	295/75R22.5

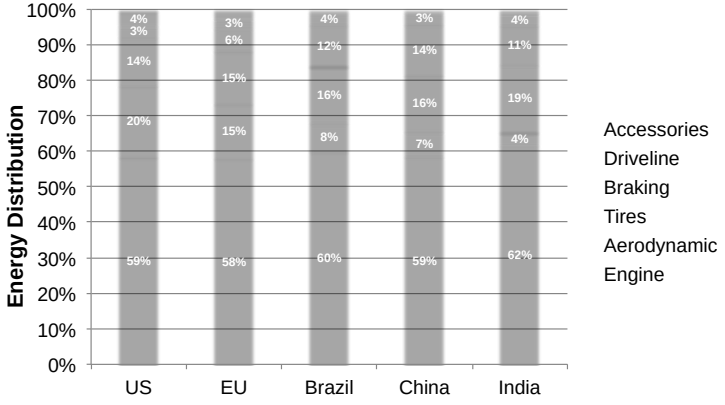
Typical duty cycles and payloads

Duty cycle	Average speed (km/h)	Representative Payload (tonnes)
Brazil - WHVC	76.3	19.5
China - WHVC	72.7	25
ACEA Long Haul	77.3	19.3
India - WHVC	32.9	27.2
US Phase 2 cycles	99.1	17.2

Fuel consumption



Energy audits

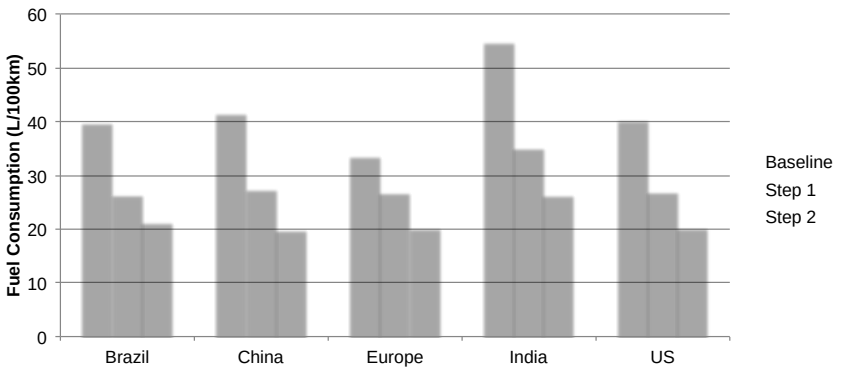


Technology potential

Assumptions

	Technology	Step 1 (US Phase 2 equivalent)	Step 2 (SuperTruck/ EPA best set)
Vehicle parameters	Engine brake thermal efficiency (BTE)	~47%[d]	~50%[d]
	Tractor aerodynamics (CdA)[a]	5.3 m^2	5.1 m^2
	Trailer aerodynamics (delta CdA)	1.1 m^2	1.6 m^2
	Tire rolling resistance (RRC)[b]	5.6N/kN (steer) 5.9N/kN (drive) 4.8N/kN (trailer)	4.3N/kN (steer) 4.5N/kN (drive) 4.3N/kN (trailer)
	Transmission type	AMT	AMT/DCT[c]
	Axle configuration	6x2	6x2
	Rear axle ratio	3.2	2.3
	Weight reduction	-	Up to 1,279 kg
Technology effectiveness	AMT transmission benefit	1.8%	2.0%
	Axle configuration benefit	1.5%	2.5%
	Downspeeding	1.8%	1.8%
	Axle lubricant	0.2%	0.5%
	Predictive cruise	0.8%	2.0%
	Accessories improvement	0.3%	1.0%
	A/C improvement	0.2%	0.5%
	Automatic inflation systems (ATIS)	0.4%	1.0%
	ATIS (trailer)	1.4%	1.5%
	Direct drive	1.0%	2.0%
	Idle reduction	3.0%	5% APU[e/] 7% other

Results

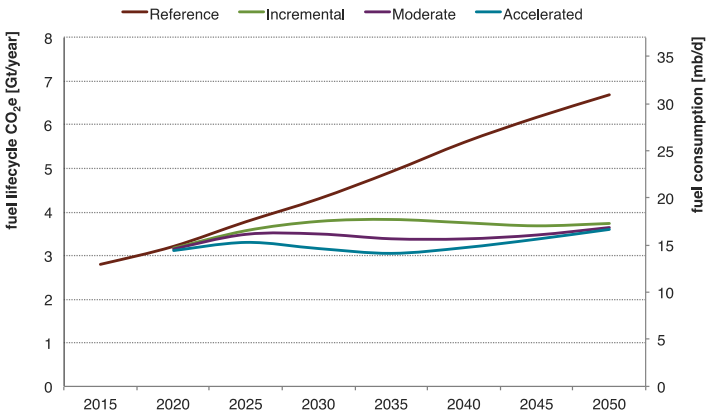


Tractor-trailers potential:

- Step 1: 20%-36%
- Step 2: 40%-52%

Global scenarios

Global GHG emissions from HDVs by efficiency scenario

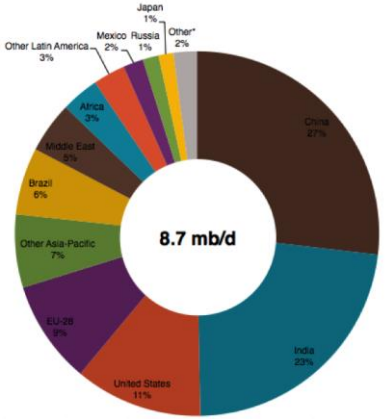


- **Reference:** Policies currently in place.
- **Incremental:** Efficiency potential reached between 2035 and 2045.
- **Moderate:** Efficiency potential reached between 2030 and 2040.
- **Accelerated:** Efficiency potential reached between 2030 and 2035.

Global sales-weighted new vehicle fuel consumption reductions by segment and scenario

Scenario	Medium HDV (6.35-15 tons)		Heavy HDV (15+ tons)	
	Annual reduction	Total reduction	Annual reduction	Total reduction
Incremental (by 2045)	1.40%	31%	2.20%	46%
Moderate (by 2040)	1.60%		2.90%	
Accelerated (by 2035)	1.80%		3.10%	

Share of worldwide potential fuel savings from accelerated tractor-trailer and rigid truck efficiency, 2035



Summary/Conclusions

- HDV sector is behind LDV sector in implementation of efficiency standards.
- Significant technology potential (~40%) exists to improve the global HDV fleet.
- Technology-forcing standards would ideally put in place to drive technology adoption.
- Pathways to zero- or near-zero emissions freight transport would ideally be developed in the near term.
  - The technologies analyzed for this study will not be enough to produce the reductions that are needed for full decarbonization of the heavy-duty sector.
- Strong compliance programs required
  - Conformity of production and in-use verification requirements are needed to ensure that regulatory requirements translate to real-world improvement and to avoid the real-world “gap” that is well documented for LDVs.

Thank you!

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Key Assumptions and Notes

- Only one GVW assumed per vehicle segment. GVW of HDVs range from 3.5t to 40+t.
- Only one configuration and technology level was assumed per vehicle segment. HDV fleets are very diverse.
- Two segments were analyzed. Relative importance of a given segment (e.g. tractor-trailers) varies at the country level.
- Market dynamics are uncertain (road infrastructure, safety regulations, size and weight regulations) no changes were assumed in:
  - Engine size
  - Payloads
  - Duty cycle
  - Trailer size and weight
  - MHD/HDV ratio
- There are considerable differences in the data available between countries (e.g. a wealth of data for the US, very few data for India or Brazil)